Quoi de neuf en astroparticules?

Damien Dornic – 22/10/07

nternational Conference on stro-Particle physics University "La Sapienza" and INFN

Roma, Italy June 20th - 22nd 2007

BICAPOT (Roma International Conference Astro-Particle physics) is the first edition of a series of International Conferences dedicated high energy cosmic rays study, organized the three public Universities and INFN tin by Sections of Roma (University and INFN of Roma "La Sapienza", University and INFN of Roma "Tor Vergata" and University and INFN of "Roma Tre"). Physicists by these institutions are deeply involved in major experiments on Astro-Particle physics, (AGILE, AMS, ANTARES, ARGO, Auger, GLAST, NEMO, PAMELA, ...) and in deep and fruitful theoretical speculations.

The RICAP Conference will be held every two years. The first edition will be held at the University of Roma "La Sapienza", the second at the University of Roma "Tor Vergata" and the third at "Roma Tre"

Conference Chairman

Antonio Capone (Univ. La Sapienza & INFN, Roma)

Local Organizing Committee

Bruno Borgia (Univ. La Sapienza & INFN, Roma) Tommaso Chiarusi (Univ. La Sapienza & INFN, Roma)



Felix Aharonian (MPIK, Heidelberg, Germany) Zhen Cao (IHEP, Belling, China) John Carr (CPPM, Marseille, France) Tom Gaisser (Univ. of Delaware, USA) Arkady Galper (Moscow Eng. Phys. Inst., Russia)

TeV Particle Astrophysics III, Istituto Veneto, Venice, Italy 27-31 August 2007

Scientific Organizing Committee

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http://www.pd.infn.it/TeV/index.html

TOPICS

"New Physics at LHC -TeV Particle Physics Connections with Cosmology

TeV Gamma-ray Astrophysics "Theoretical aspects "Ground-Based Experiments (ARGO-YBJ.

CANGAROO, HESS, MAGIC, Milagro, STACEE, TACTIC, Tibet, VERITAS): latest results and future plans Upcoming Space Telescope GLAST

Direct and Indirect Dark Matter Searches -Update on direct searches

•New strategies of indirect detection First PAMELA results

Neutrino Telescopes Amanda, Antares, Baikal, IceCube, Nemo, Nestor, KM3NeT

-Ultra-High Energy Cosmic Rays Latest AUGER results Acceleration and propagation





IUMA UNAR CONACTONADE WAR CINVESTAN WAD'L UMSNIP

ICRC program: -1100 comitionitons

SH: Solar and Heliospheric Phenomena (~250 papers)

- SH 1: Sun and Corona
- SH 2: Transient Phenomena in the Heliosphere
- SH 3: Galactic Cosmic Rays in the Heliosphere
- SH 4: Anomalous component in the heliosphere
- SH 5: Cosmic Rays at the Termination Shock and in the Heliosheath

OG: Cosmic Ray Origin and Galactic Phenomena (~400 papers)

- OG 1: Cosmic Ray Origin
 - OG 2: X-ray, Gamma-ray and Neutrino Astronomy and Astrophysics

HE: High Energy Phenomena (~450 papers)

- HE 1: Extensive Air Showers and UHE Cosmic Rays
- **HE 2: Muons and Neutrinos**
- HE 3: Interactions, Particle Physics Aspects, Astroparticle Physics and
- Cosmology

Main topics

 Gamma-ray Astrophysics: theoretical aspects, latest observational results from ground based experiments (H.E.S.S., MAGIC, VERITAS), prospects for AGILE and GLAST, future plans for a large gamma-ray infrastructure

 Neutrino telescopes: Status and future plans for Antares, Baikal, IceCube, Nemo, ANITA and future plans for a large km3 experiment

 Ultra-High Energy Cosmic rays: update on acceleration and propagation, latest observational results from AUGER, prospect on R&D detection

 Dark Matter: new strategies for indirect detection, present and future of direct searches, first results from the anti-matter space detector PAMELA

VHE INSTRUMENTS

MILAGRO



A MAJOR NEW INSTRUMENT







KIFUNE PLOT



VHE Source Numbers

Class	2003	2005	2007
PWN	1	6	18
SNR	2	3	7
Binary	0	2	4
Diffuse	0	2	2
AGN	7	11	19
UnId	2	6	21
Total	12	33	71!

Galactic sources & Diffuse emission

APOD 2006/06/02

Radio/X-ray image IC 443 @ 1.5 kpc ~30 kyr age

MOST Radio image RCW 86 @ 1-3 kpc ~1.6-10 kyr age

Radio/IR image W28 @ 2-3 kpc 35 – 150 kyr age Brogan et al. 2006 20/90 cm VLA MSX 8 micron

THE NEW GALACTIC VHE γ -Ray Sources

Name	Discovered	Class	Contributions (detections)
Cyg X-1?	MAGIC	Binary	MAGIC
LS I +61 303	MAGIC	Binary	MAGIC, VERITAS
RCW 86	HESS	SNR	HESS
IC 443	MAGIC	SNR?	MAGIC, VERITAS
W 28	HESS	SNR?	HESS
Kes 75	HESS	PWN/SNR	HESS
G21.5-0.9	HESS	PWN/SNR	HESS
HESS J1023-575	HESS	Stellar Cluster?	HESS
MGRO J2031+41	Milagro	?	Milagro
MGRO J2019+37	Milagro	?	Milagro, Tibet
MGRO J1908+06	Milagro	?	Milagro, HESS
HESS J0632+057	HESS	Binary?	HESS
HESS J1718-385	HESS	PWN?	HESS
HESS J1809-193	HESS	PWN?	HESS
HESS J1912+102	HESS	PWN?	HESS A
HESS J1357-645	HESS	PWN?	HESS
+7 UnId sources!	HESS	?	HESS

La population primaire: des électrons ?

Electrons: loi de puissance d'indice 2.4 + coupure exponentielle à 80 TeV
Energie injectée: 10⁵⁰ erg
Facteur électron/proton: ~ 3 × 10⁻²



RX J1713-3946



La population primaire: des protons ?

- Distribution des protons : loi de puissance + coupure exponentielle $E_{cut} = 120 \text{ TeV}$ et indice = 1.98
- Energie injectée = 10⁵⁰ ergs
- Facteur électron/proton = 5×10^{-4}
- Champ magnétique = $35 \ \mu G$ et Densité = $1.5 \ cm^{-3}$









New development



MILAGR

Milagro technique now clearly works!



Have all-sky monitoring and survey capabilities at TeV energies.



Complements classical ICT method very nicely.



Veníce TeV2007 Aug 28

MILAGRO SOURCES AND CANDIDATES

- 7 year map
- γ/hadron cut raises median energy to 20 TeV
- 3 new sources significant post trials
- 4 'hotspots'
- Interesting regime of hard spectrum/ extended sources





DIFFUSE EMISSION WITH MILAGRO



- Galactic plane emission, factor 2 higher than diffuse predictions, seems consistent with ~50% unresolved sources
- Large scale (>10 deg) features seen in `proton-like' events interesting, but not gamma-ray astronomy – apparently related to the tail-in anisotropy seen by Tibet Walker 672

HESS GALACTIC PLANE SURVEY



Survey region was extended in the years 2005 – 2007 – many new sources EGRET



Le relevé du plan galactique: notre galaxie dévoilée en gamma

Sources > 4σ : 16 nouvelles (18 total), ApJ 636 (2006) 777



W 28



- TeV emission around old (>10⁴ year old) SNR coincident with molecular clouds
 First evidence for p-p in SNR/Cloud interactions
 - See e.g. Aharonian, Drury & Voelk 1996

IC 443

MAGIC 5.7 or in 29 h
Steep spectrum E -3.1±0.3

- VERITAS 7.1 or in 16 h
 Consistent position
- Position compatible with dense gas, not PWN, not shell
 Interaction of hadrons accelerated in SNR?
 Morphology may be key to interpretation



X-ray filaments → large magnetic field

Chandra Cassiopeia A Chandra SN 1006

PULSAR WIND NEBULAE

- Major galactic TeV source population
 - C Associated with relatively young (<10⁵ year old) and energetic pulsars
- Generally believed that we see inverse Compton emission of 1-100 TeV electrons



ENERGY DEPENDANT MORPHOLOGY

0.2 - 0.8 TeV 0.8 - 2.5 TeV Above 2.5 TeV



HESS J1825-137 associated with energetic pulsar

- Spectral steepening seen away from the pulsar
- Very likely this is evidence for cooling of electrons in the Nebula

Seen in several X-ray PWN

A first in gamma-ray astronomy!



New PWN CANDIDATES



THE CRAB NEBULA





GAMMA-RAY BINARIES





LS 5039 WITH HESS

- Strong modulation of flux and spectrum with orbital phase
 - Beautifully measured!
- Maximum is when star lies in front of compact object along the line of slight
- Absoption/ cascading effects?



New HESS Sources Without Counterpart





What are they?

(a) Sources "without" electrons:
 GRB remants (Atoyan et al.)



 Old supernova remnants (Yamazaki et al.)
 Stellar clusters / stellar winds / OB assoc.

(b) "hidden" electrons? e.g. HESS J1616-508



GEV ACTIVITY



- Understanding the diffuse background
 - really critical for galactic sources **Porter** 762, 766
- Expected science performance
 - Blazars
 - Pulsars (importance of radio ephemerides) Guillemot 1286

Carson 1211

Orlando 606

Davoudifar 507

(**Baughman** 1116)

- Also IC halos around massive stars
- AGILE
 - Blazar obs. together with TeV instruments Persic 363
- EGRET reanalysis and interpretation
 - Catalogue revision (diffuse model change) (Casandjian 155
 - Excess from the Coma direction
 - Galactic diffuse emission –
- Studies relating GeV and TeV emission...

Ciel gamma EGRET -> GLAST



13

GLAST

10-15 septembre 2007

Ecole de physique des astroparticules
Origine de l'émission gamma

- Deux possibilités :
 - Origine hadronique : collisions des protons de haute énergie -> π°->γγ
 - Origine leptonique : électrons de haute énergie
 - Synchrotron
 - Compton inverse sur des photons ambiants
- En mesurant entre 30 MeV et 300 GeV, GLAST devrait pouvoir différencier les deux scénarios :
 - Dans le cas leptonique, le spectra gamma en dessous de 100 GeV doit être dur (à cause du spectre synchrotron)

10-15 septembre 2007

Ecole de physique des astroparticules





2ª dN/dE (eV cm⁴² s⁻¹

THE GEV/TEV CONNECTION

- Do we see the same source populations in the GeV and TeV domains?
 - Sensitivity mismatch of a factor 60 (EGRET lifetime / 5 h HESS survey)
- Not many EGRET/TeV positional coincidences
 - But those that exist have `matching' spectra
 - This is expected by chance
- Also MILAGRO/EGRET coincidences seem statistically significant

Very extended objects?



Extragalactic sources - AGNs - GRBs

EXTRAGALACTIC VHE GAMMA-RAY SOURCES

	Name	Discovered	Year	Z	Contributions
	M 87	HEGRA	2003	0.004	VERITAS-Colin, HESS-Beilicke, MAGIC-
	Mrk 421	Whipple	1992	0.031	MILAGRO-Smith, VERITAS-Fegan, +
	Mrk 501	Whipple	1996	0.034	TACTIC-Godambe, MAGIC-Paneque, +
	1ES 2344+514	Whipple	1998	0.044	MAGIC-Wagner
-	Mrk 180	MAGIC	2006	0.046	MAGIC-Mazin
	1ES 1959+650	TA	2002	0.047	MAGIC-Hayashida
→	BL Lac	MAGIC	2006	0.069	MAGIC-Hayashida
->	PKS 0548-322	HESS	2006	0.069	HESS-Superina
	PKS 2005-489	HESS	2005	0.071	HESS-Costamante
	PKS 2155-304	Durham	1999	0.116	HESS-Punch, CANGAROO-Sakamoto, +
	H 1426+428	Whipple	2002	0.129	VERITAS-Krawczynski
+	1ES 0229+200	HESS	2007	0.140	HESS-Raue
	H 2356-309	HESS	2005	0.165	HESS-Costamante
	1ES 1218+304	MAGIC	2005	0.182	MAGIC-Hayashida
	1ES 1101-232	HESS	2005	0.186	HESS-Puelhofer
1	1ES 0347-121	HESS	2007	0.188	HESS-Raue
->	1ES 1011+496	MAGIC	2007	0.212	MAGIC-Mazin
	PG 1553+113	HESS/MAGIC	2005	?	MAGIC-Wagner, HESS-Benbow
+	3C 279	MAGIC	2007	0.536	MAGIC-Teshima

EXTRAGALACTIC BACKGROUND ABSORPTION





Le fond diffus extragalactique (2)



Le fond diffus extragalactique (2)



(M. Lemoine-Goumard)



BL LAC



First Low energy peaked BL Lac observed at VHE energies

Steep (Γ = -3.6±0.5), not due to absorption – intrinsic low energy peaked source

There will be many more if we reach lower sensitivity!



The most distant: MAGIC - 3C 279 (z=0.536)

Wehrle et al., ApJSS 133 (2001) 297

Flat spectrum radio quasar (FSRQ) Strong and flaring EGRET blazar Superluminal motion $\beta > 0.99c$, jet angle 2°-4° δ =12-21 Piner et al, ApJ 588 (2003) 716



ЗС 279: ОNE NIGHT, 23RD FEB 2006



MRK 501 FLARES



- June 30th flare has ~3 minute variability (but is not so strong statistically), July 9th better measured but slower
- First big flare seen by a third generation Cherenkov instrument
- But...



No spectral variability compared to the low state

=> Causality arguments give to limit in the radius of emission



- GRB 060602b simultaneous observation with HESS by chance (2.5°)!
- But no redshift found and may have been a galactic X-ray burster

EXPERIMENTAL WORK: UPPER LIMITS



EXPERIMENTAL WORK

Several challenges for VHE GRB observations

- Redshift reach limited by EBL absorption to << 1</p>
 - Roughly one third of GRBs
 - Relatively small fraction have measured redshift without which limits are not meaningful
- IACTS
 - Limited duty cycle, small FoV, response time
- Non-Imaging
 - Sensitivity (angular resolution, eff. area, threshold)
- Many instruments routinely follow GRB triggers
 - Whipple, VERITAS, MAGIC, HESS, STACEE,...
 - Wide field of view instruments such as Milagro get more bursts with zero delay – but worse sensitivity
 - Several years of follow-up observations...



Les instruments

γ mous: E < 10 MeV INTEGRAL



γ de haute énergie: 10 MeV < E < 100 GeV EGRET, AGILE, GLAST





 γ de très haute énergie E > 100 GeV HESS, VERITAS...



Summary

- VHE γ-rays is currently a very active field
- Number of sources is rising rapidly but also the precision with which the bright sources can be measured
 - E.g. Energy dependent morphology in HESS J1825-137, 6" location acc. at the Galactic Centre with H.E.S.S.
- The redshift range has been more than doubled!
 - MAGIC detection of 3C 279
- Expect >100 VHE sources at the next ICRC
 - VERITAS is now fully operational
 - First MAGIC-II sources?
- and >1000 GeV sources from GLAST!

Now **REAL** Astronomy at TeV energies!



Surveys and catalogues



Images and maps



Light curves



And two complementary methods!



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 Ultra-High Energy Cosmic rays: update on acceleration and propagation, latest observational results from AUGER, prospect on R&D detection

The unified spectrum of neutrinos



V

Tel



Charge Ratio Model Results

-First high-statistics measurement of muon charge ratio in TeV energy range



- MINOS measure μ + / μ ⁻ and fit to formulas
- best fit values: $f_{\pi^+} = A_{\pi^+} / A_{\pi^-} = 0.55$; $f_{K^+} = A_{K^+} / A_{K^-} = 0.67$

Implications for > TeV atm v

$$\begin{array}{l} f_{K+} = 0.67 \rightarrow A_{N \rightarrow K^+} \,/\, A_{N \rightarrow K^-} \,=\, 2 \\ \mbox{Substantial contribution of associated} \\ \mbox{production (} p \rightarrow \Lambda \, K^+ \,) \\ \mbox{Effect is amplified for v's: } \nu_{\mu} / \nu_{\mu} \rightarrow 2 \\ \mbox{Important for atmospheric neutrino} \\ \mbox{background in neutrino telescopes} \\ \mbox{MINOS measurement will lead to improved} \\ \mbox{calculation of >TeV } \phi_{\nu} \end{array}$$

MINOS

Super-Kamiokande and status of neutrino oscillations

- SK-III operating since July 12, 2006
- Hardware and software upgrades
- Full complement of >11 thousand 20" PMTs plus outer (veto) detector
- Recalibration finished and first year data in good agreement with SK-I + SK-II
- Potential for lower threshold for solar neutrino analysis



All distributions agree with oscillated expectations

Neutrino oscillation status

- L/E dip seen at first oscillation minimum
- No evidence yet for any non-standard oscillations, only upper limits for

sterile neutrinos

oscillations increasing with energy

No sign yet of possible second-order oscillation effects

three-neutrino effects

 θ_{13}

MINOS in NuMi beam results consistent with SK

S-K Summary (SN burst search)

3 methods of supernova searches with newly installed criteria was conducted.

Data set : from May 1996 to Oct 2005 :Total livetime: 2589.3 days (Livetime for 3rd analysis : 2381.3 days)

No candidate was observed

100% detection probability up to 100 kpc SN rate within 100kpc(LMC,SMC,our Galaxy) is estimated < 0.32 SN/yr @ 90% C.L.

Detection probability is maintained at a level of 7% for SN at Andromeda.

No candidate of neutronization burst observed





strings and tank stations

Completion by 2011.

Neutrinos in IC9



Achterberg et al. astro-ph/0705.1781

- 9-string data (2006)
- Cosmic ray background seen with weak cuts
- Atmospheric neutrinos seen with strong cuts
- Agreement in event rate over
 6 decades



Spiering TeV-III

Data Sample

Data taking in 2006 from beginning of June until end of November

Total livetime: 137.4 days

233 neutrino candidate events selected by cuts.

From simulation, expect background of:

- 227 atmospheric neutrinos (Bartol spectrum)
- < 10% mis-reconstructed downgoing muons



Data Sample



Merida, Mexico C. Finley - 9 String IceCube Point Source Analysis



Atmospheric neutrinos



Tel

Search for diffuse v flux

AMANDA-II 2000-2003 integrated analysis Upper Limit






AMANDA-II: 2000-2004 (1001 live days) 4282 v from Northern hemisphere

No significant excess found

Search for neutrinos from 32 candidate sources



event selection optimized for both $dN/dE\ {\rm \sim}E^{-2}$ and E^{-3} spectra

Achterberg et al. astro-ph/0611063	source	nr. of v events (5 years)	expected background (5 years)	E ⁻² flux upper limit (90% c.l.) $\Phi_{\nu_{\mu}+\nu_{\tau}}^{\nu_{\mu}+\nu_{\tau}}$ [10 ⁻¹¹ TeV ⁻¹ cm ⁻² s ⁻¹]	No signi
	Markarian 421	6	7.4	7.4	fica
1.2 σ equiv. (random maps)	M87	6	6.1	8.7	Inte
	1ES 1959+650	5	4.8	13.5	exc
	SS433	4	6.1	4.8	ess
	Cygnus X-3	7	6.5	11.8	0 B
	Cygnus X-1	8	7.0	13.2	Ser
	Crab Nebula	10	6.7	17.8	Vec
	3C 273	8	4.72	18.0	

First IceCube All-Sky Map



Data Events (points); Galactic Plane (curve)

Results:

The maximum deviation is 3.35 sigma, at r.a. = 276.6°, dec = 20.4°.

Random clustering of background: 60% of simulated background trials (data scrambled in right ascension), have a maximum deviation (anywhere) of 3.35 sigma or greater.

Chance probability of the hottest spot = 60% ... not significant.

Merida, Mexico

ANTARES: Conclusions and Outlook



Antoine Kouchner

- Major step forward during the last year
- Detector working well within design specifications:
 - Junction Box in operation since Dec. 2002
 - 5 lines delivering data on the site
 - All technical problems solved
- ▶ 12 lines detector complete early 2008:
 Operation for science ≥ 5 years
- Milestone towards a KM³ underwater detector

Candidates for

first undersea neutrino !!

Zenith angle distribution









Quest for cosmogenic v

- Motivated by indication of GZK feature in UHE cosmic-ray spectrum
- Cosmogenic v (from p + $\gamma_{2.7}$ \rightarrow n + π^+ \rightarrow v)
 - Probe evolution, composition, spectra of extragalactic cosmic-ray sources
 - Goal: >1000 km³sr, > 100 events/yr, E >10¹⁸ eV
 - RICE, AURA, ANITA, ARIANNA at this conference
 - Acoustic detection in Ice another possibility

Model dependence of cosmogenic v



>PeV v absorbed in the Earth



Overview

Radio in ice: - RICE, ANITA, AURA, ARIANNA-type (all Antarctica), SALSA (salt) Radio in Moon⁻ - GLUE, NuMOON, ... Radio in air: - FORTE (from space), LOPES, Horizontal air showers: - AGASA, HiRES, Auger, EUSO, ... Acoustic detection: SAUND (Caribbean), SPATS (South Pole), AMADEUS & others (Mediterranean), Baikal, SALSA (salt dome), Permafrost (Siberia), ...

Tel

Spiering



Detector was tested in pulsed electron beam at SLAC – J. Kowalski





Spiering TeV-III

Present and projected limits and event numbers



- RICE limits, 3500 hours
- GLUE limits, 120 hours
- ANITA sensitivity, 45 days total:
 ~5 to 30 GZK neutrinos
- IceCube: high energy cascades
 ~1.5-3 GZK events in 3 years
- Auger: tau neutrino decay events
 a ~1 GZK event per year?

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Status of Auger





*** Determine the Origin of UHECRs ***

Energy Spectrum features? ankle, GZK; injection? Propagation?

Composition protons, nuclei, photons, neutrinos

Arrival Direction Distribution anisotropies?

Auger reconstruction techniques	Hybrid	Era	
	HYBRID	SD only	FD only
Energy	A & M indep	depend	independ
Aperture	E, A, M indep	independ	depend
Angular Resolution	~ 0.2°	~1-2°	~3-5°
[E <mark>= en</mark> ergy, A= mass,	M = hadronic	model

Auger: energy calibration



Selection of high quality hybrid data without introducing biases (talk on elongation rate by M. Unger [Auger Collaboration])

⇒ 387 events

 \Rightarrow Correlation of S_{38°} and E_{FD}

Energy resolution



Uncertainty on the energy scale

sour	<u>ce</u>	<u>systema</u>	tic uncerta	<u>iinty</u>	
Fluorescence yield		14%	AirFly	nte	
P, T and humidity effects		cts	7%	measuremen	113
Calibration			9.5%		
Atmosphere			4%		
Reconstruction			10%		
Invisible	e energy		4%		
Total:			22%		
	(improvements expected soon)				









Auger Aperture is INDEPENDENT of models, mass or assumptions about **F**

This is NOT the case for HiRes, problem with HiRes aperture?

Spectrum facts

There is an ankle



How to interpret it?

Galactic/Extragalactic transition? or Spectral feature from pair-production energy losses of pure-proton UHECRs?

There is a "cut-off"

How to interpret it?

GZK suppression? or Limit of the acceleration process?

 \implies analyse composition! \implies analyse arrival directions!







*** Determine the Origin of UHECRs ***

Energy Spectrum features? ankle, GZK; injection? Propagation?

Composition protons, nuclei, photons, neutrinos

Arrival Direction Distribution anisotropies?





Auger 20years operation will reach to GZK gamma flux of ~0.1%





Auger Xmax suggests mixed composition HiRes claimed proton dominance above10¹⁸eV



*** Determine the Origin of UHECRs ***

Energy Spectrum features? ankle, GZK; injection? Propagation?

Composition protons, nuclei, photons, neutrinos

Arrival Direction Distribution anisotropies?

Auger anisotropy results

Angular resolution of ~1°: good enough!

No large-scale signal (dipole) at any energy above 1 EeV e.g. $\alpha < 0.7\%$ for 1 EeV $\leq E \leq 3$ EeV

No signal from BL-Lacs as possibly seen by HiRes

 \implies none of the previous reports has been confirmed...

Two prescriptions are being tested... Stay tuned!

Auger: Galactic Center

$1 < E < 10 \ EeV$



 $\rm E < 1 \ EeV$





HiRes Anisotropy Negative excess at Anti-G.C.

Significance plot for $10^{17.5} < E < 10^{18.5} \text{ eV}.$



Akeno/AGASA result



Many open questions

• Energy scale problem

- 1.2~1.5 factor between Auger and other experiments
- FD energy (FY) $\leftarrow \rightarrow$ SD energy (MC energy calibration)

• What is ankle?

- − Pair creation dip → V.Berezinsky
- Transition from galactic to extragalactic

• Chemical composition at UHE

- − Proton dominance ? → support pair creation dip hypothesis
- Mixed composition \rightarrow photodisintegration energy (Eth \sim A) \rightarrow Support Auger Xmax?

• Break in energy spectrum at 4x10¹⁹eV

- GZK Cutoff?
- Acceleration limit?
- Drop off of lighter elements?

• Medium scale anisotropy

- Relating with large scale structure?
- Deflected images of point sources (North-South asymmetry)




Telescope Array: 512 scintillators + 3 FD sites ~95% construit + en phase de commissionning + Tale (exetension à basse énergie)



The Pierre Auger Observatory – 2 Sites Need for 2 sites realized since beginning of project

Northern Site: Colorado





Jem-EUSO: sur l'ISS vers 2013



Résumé

- Foisonnement d'activités expérimentales
- Amélioration très impressionnant de la qualité des mesures
- Analyse multi-messagers

Figments, Fictions and Fantasies



Thèmes non abordés, mais pourtant au combien intéressants !!!

• CR: from knee to ankle

Tibet-AS, KASCADE-Grande

Understanding of cosmic ray interactions

Reliability of interpretation of air shower data, cross section measurements, simulation tools and related questions, accelerator data...

• Matter and anti-matter in CR

CREAM, ATIC, PAMELA ...

• Dark matter direct searches

Liquid noble gases experiments have shown dramatic progress during the last year (XENON10...)

•